IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Robert Freedman	)
Serial No.:	10/064,727	)
Filed:	August 8, 2002	)
Title:	Combining NMR, Density and High Frequency Dielectric Logging Measurements for Improved Formation Evaluation	)

Attorney Docket No.:	20.2760
Group Art Unit:	2859
Examiner:	T. Fetzner

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Kerry Morris 8/30/05
Kerry Morris Date

Response and Amendment

Assistant Commissioner for Patents
Washington, D. C. 20231

Dear Ma'am:

In response to the Office Action dated March 3, 2005, please enter the following response and amendment.

Introductory Remarks

Claims 5, 10,16, 20-24 and 29 are objected to for lack of antecedent basis. These claims have been amended to correct the defect or cancelled. Claims 1-5, 8, 10-12 and 30 are rejected under 35 USC 102(b) as being anticipated by Lew. Claims 6, 7, 31 and 32 are rejected under 35 USC 103(a) as being unpatentable over Lew. Claims 28 and 29 are rejected under 35 USC 103(a) as being unpatentable over Schoen. Applicant acknowledge the

indication of allowability for claims 9, 13 and 15-24. Claims 1-24 and 28-32 remain under consideration in this application.

Claim Amendments

1. (Previously Presented) A method for making formation evaluation determinations, comprising:

acquiring a nuclear magnetic resonance measurement of an earth formation;

acquiring a dielectric measurement of the earth formation; and

determining an oil volume fraction of the earth formation from a combination of the nuclear magnetic resonance measurement and the dielectric measurement.

2. (Original) The method of claim 1, wherein the nuclear magnetic resonance measurement comprises at least one spin echo amplitude.

3. (Original) The method of claim 2, wherein the acquiring the nuclear magnetic resonance measurement uses a polarization time sufficiently long so that nuclear spins are substantially polarized.

4. (Original) The method of claim 1, wherein the dielectric measurement comprises an electromagnetic wave phase shift.

5. (Cancelled)

6. (Original) The method of claim 5, wherein the acquiring the nuclear magnetic resonance measurement and the acquiring the dielectric measurement are performed while drilling.

7. (Original) The method of claim 5, further comprising:

determining a water-filled porosity from the dielectric measurement;

determining a total formation porosity from the nuclear magnetic resonance measurement; and

determining an oil-filled porosity by subtracting the water-filled porosity from the total formation porosity.

8. (Original) The method of claim 5, wherein the dielectric measurement comprises an electromagnetic wave attenuation.

9. (Original) The method of claim 8, further comprising:

determining a total formation porosity from the nuclear magnetic resonance measurement; and

calculating a salinity of a brine in the formation based on the total formation porosity and a known aqueous phase attenuation function with respect to the salinity and a formation temperature.

10. (Currently Amended) The method of claim 1, wherein the the formation evaluation determinations are based on formation fluids ~~comprise~~comprising at least one sample withdrawn from a formation traversed by a borehole, and a sum of an oil volume fraction and a water volume fraction is taken to be one.

11. (Original) The method of claim 10, further comprising:

determining a total volume of the formation fluids from the nuclear magnetic resonance measurement;

determining the water volume fraction of the formation fluids from the dielectric measurement; and

determining the oil volume fraction of the formation fluids by subtracting the water volume fraction of the formation fluids from the total volume of the formation fluids.

12. (Original) The method of claim 10, wherein the dielectric measurement comprises an electromagnetic wave attenuation.

13. (Original) The method of claim 12, further comprising calculating a salinity of a brine in the sample based on a total volume of the formation fluids and a known aqueous phase attenuation function with respect to the salinity and a fluid temperature.

14. (Previously Presented) A method for making formation evaluation determinations, comprising:

acquiring a nuclear magnetic resonance measurement of an earth formation;

acquiring a dielectric measurement of the earth formation;

acquiring a bulk density measurement of the earth formation;

forming a set of linear response equations representing a reservoir fluid model; and

solving ~~a~~ the set of linear response equations to determine fractional fluid volumes of the earth formation from a combination of the nuclear magnetic resonance measurement, the dielectric measurement, and the bulk density measurement.

15. (Original) The method of claim 14, wherein the reservoir fluid model comprises a representation of a non-gas bearing formation, the fractional fluid volumes comprise a water volume fraction, an oil volume fraction, and an oil-based mud filtrate volume fraction, and the set of linear response equations comprises:

a nuclear magnetic resonance response equation that defines a total volume of the formation fluids with respect to the oil volume fraction, the water volume fraction, and the oil-based mud filtrate volume fraction.

a dielectric response equation that defines an electromagnetic wave travel time with respect to the oil volume fraction and an oil travel time, the water volume fraction and a water travel time, and the oil-based mud filtrate volume fraction and an oil-based mud filtrate travel time; and

a density response equation that defines the bulk density with respect to an oil density and the oil volume fraction, a water density and the water volume fraction, and an oil-based mud filtrate density and the oil-based mud filtrate volume fraction.

16. (Currently Amended) The method of claim 15, wherein the formation evaluation determinations are based on formation fluids ~~comprise~~comprising fluids in a formation traversed by a borehole drilled using an oil-based drilling fluid, the electromagnetic wave travel time is a formation electromagnetic wave travel time, the bulk density

comprises a formation bulk density, the total volume of the formation fluids comprises a total formation porosity, the oil volume fraction comprises an oil-filled porosity, the water volume fraction comprises a water-filled porosity, and the oil-based mud filtrate volume fraction comprises an oil-based mud filtrate porosity.

17. (Original) The method of claim 16, wherein the oil-filled porosity and the oil-based mud filtrate porosity are inseparable and the reservoir fluid model comprises a water phase and a combined oil and oil-based mud filtrate phase.

18. (Original) The method of claim 16, wherein the dielectric measurement comprises a measurement of a complex dielectric constant of the formation.

19. (Original) The method of claim 16 further comprising calculating a salinity of a connate water in the formation based on the total formation porosity and a known aqueous phase attenuation function with respect to the salinity and a formation temperature.

20. (Currently Amended) The method of claim 15, wherein the formation evaluation determinations are based on formation fluids ~~comprise~~comprising at least one sample taken from a formation traversed by a borehole, and a sum of the oil volume fraction, the water volume fraction, and the oil-based mud filtrate volume fraction is taken to be one.

21. (Original) The method of claim 20, wherein the at least one sample is withdrawn such that it comprises substantially native formation fluids and the oil-based mud filtrate volume fraction is zero.

22. (Currently Amended) The method of claim 14, wherein the reservoir fluid model comprises a representation of a gas-bearing formation, the fractional fluid volumes comprise a gas volume fraction, a water volume fraction, and a gas-corrected total volume, and the set of linear response equations comprises:

an nuclear magnetic resonance response equation that defines ~~the~~ a total volume of ~~the~~ formation fluids with respect to the gas volume fraction, a water volume fraction, and a gas-corrected total volume;

a dielectric response equation that is adapted for the gas-bearing formation by defining an electromagnetic wave travel time with respect to the gas volume fraction and a gas travel time, the water volume fraction and a water travel time, and the gas-corrected total volume and a gas-corrected travel time; and

a density response equation that is adapted for the gas-bearing formation by defining the bulk density measurement with respect to the gas volume fraction and a gas density, the water volume fraction and a water density, and the gas-corrected total volume and a gas-corrected total density.

23. (Original) The method of claim 22, wherein the formation fluids comprise fluids in a formation traversed by a borehole, the electromagnetic wave travel time is a formation electromagnetic wave travel time, the bulk density comprises a formation bulk density, the total volume of the formation fluids comprises a total formation porosity, the gas volume fraction comprises a gas-filled porosity, the water volume fraction comprises a water-filled porosity, and the gas-corrected total volume comprises a gas-corrected total formation porosity.

24. (Original) The method of claim 22, wherein the formation fluids comprise at least one sample taken from a formation traversed by a borehole, and a sum of the gas-filled porosity and the water-filled porosity is taken to be one.

25. (Canceled)

26. (Canceled)

27. (Canceled)

28. (Previously Presented) A method for making formation evaluation determinations, comprising:

acquiring a nuclear magnetic resonance measurement of an earth formation;

acquiring a dielectric measurement of the earth formation; and

determining a rock-matrix travel time associated with the earth formation from a combination of the nuclear magnetic resonance measurement and the dielectric measurement.

29. (Currently Amended) The method of claim 28, further comprising determining a rock-matrix travel time log as a function of a borehole depth.

30. (Previously Presented) A method for determining a gas fractional volume in a gas-liquid sample, comprising:

acquiring a bulk density measurement of the gas-liquid sample;

acquiring a nuclear magnetic resonance measurement of the gas-liquid sample; and

determining the gas fractional volume of the gas-liquid sample from a combination of the bulk density measurement and the nuclear magnetic resonance measurement.

31. (Original) The method of claim 30, further comprising computing a density porosity from the bulk density measurement and a fluid density, and wherein the determining the gas fractional volume is performed using the density porosity and the nuclear magnetic resonance measurement.

32. (Previously Presented) A method for making formation evaluation determinations, comprising:

acquiring a dielectric measurement of an earth formation;

determining a dielectric-derived water volume of the earth formation from the dielectric measurement;

acquiring a suite of nuclear magnetic resonance measurements of the earth formation;

deriving a water volume of the earth formation and an apparent heavy oil volume of the earth formation from the nuclear magnetic resonance measurements; and

comparing the dielectric-derived water volume with the nuclear magnetic resonance derived water volume and the apparent oil volume to produce a true heavy oil volume of the earth formation.

Remarks

102 Rejections

Lew has been cited for the describing a combination of NMR measurements with dielectric and/or bulk density measurements. In support of this position, the Office Actions focuses on the appearance of the word "dielectric" in the text of Lew. For example, the Office Action cites a sentence from Lew that "[w]ater is electrically conductive, while oil is a dielectric medium" to relate Lew's disclosure to the present invention. However, Lew does not in any way teach or suggest the making or using of dielectric measurements. Even more specifically, Lew nowhere teaches a combining of the density, dielectric constant, and NMR to compute more accurate fluid volumes. Indeed Leu et al. do not teach anything about measuring or using dielectric constant data.

Lew's discussion of 'dielectric' matters relates only relative dielectric constant values of water and oil, water having a much higher dielectric property compared to oil. Nowhere does Lew disclose a specific dielectric measurement, much less a method or apparatus to make such measurements. Applicant describes typical dielectric measurements at least beginning at paragraph 7, e.g. taken by a microwave or high-frequency dielectric tool. Instead Lew relates only to the making of NMR measurements.

Lew's mention of rf emissions relates only to the NMR measurements. At col. 4, lines 44-59, Lew describes the measurement of the NMR measurement of a free induction decay (FID) by comparing amplitudes of rf emissions generated between pulses of an NMR acquisition sequence. (cite to OA that this rf emission and FID are not dielectric quantities) In fact, Lew defines its measurement of rf emissions as an NMR quantity. (See col. 2:44-67 and col. 15:67 – col. 16:2) There is simply no disclosure of any measurements other than NMR measurements. Thus, there is no support for a combination of NMR measurements with any other type of measurement.

With respect to claim 30, the Office Action cites a section of Lew mentioning 'bulk density' at col. 2:28-39. However, this section only discusses the short-comings of previous approaches to determine cut-ratios. Specifically, this section states that a small change in oil density results in a large error. However, this section nowhere suggests that a combination of NMR measurements with bulk density measurement is desirable or useful. Further, there is nothing in the remainder of the Lew patent that explicitly or implicitly discloses such a combination. Instead, as described above, Lew relates exclusively to the use of NMR measurements alone. (See Abstract) There is simply no discussion in Lew of making or using measurements other than that obtained with an NMR acquisition.

CONCLUSION

The Applicants believe this paper is fully responsive to each and every ground of rejection and objection cited by the Examiner, and respectfully request that the application proceed to grant.

Please charge any applicable fees, or apply any excess, to deposit account number 19-0610.

Respectfully submitted,

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August 30, 2005

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From	**Kerry Morris**	Date	**August 30, 2005**
Subject	**U.S. Serial Number 10/064,727**	Pages (inc)	**12**

Attached please find a courtesy copy of the Response to the Office Action dated March 3, 2005.